

APPENDIX C

AVAILABILITY ANALYSIS OF EXAMPLE FACILITY SYSTEMS

Introduction:

Coinciding with the development of the technical manual, an availability (inherent) analysis of the electrical and mechanical delivery concept model was done. The primary focus of the study was to demonstrate that the model was capable of providing 6-9s availability to the mission critical area (zone 5).

To show the robustness and interaction of key components for both electric and heating ventilation and air conditioning (HVAC) designs, both elements were incorporated into a single availability model, taken directly from the descriptors presented in the main portion of the technical manual. The “Go” methodology (a software program that utilizes Boolean algebra to calculate reliability and availability metrics) was selected and used to calculate availability metrics for both the electrical and mechanical systems.

Modeling Assumptions:

- Automatic transfer switches are actually circuit breakers controlled by programmable logic controllers (PLCs).
- PLCs within each “general” zone are considered single units and provide control for the electric and HVAC systems within the specified zone.
- PLCs located within the command center (zone 5) are modeled in pairs for redundancy considerations and control electric and HVAC operations within zone 5. Additionally, they operate isolation valves at the points where chilled and returned water for supporting zones (1-4) enter.
- Mission critical mechanical power is supplied to the mission by mechanical ‘A’ (MECH ‘A’) and mechanical ‘B’ (MECH ‘B’).
- Mission critical electric power is supplied to the mission by uninterruptible power supply ‘A’ (UPS ‘A’), and uninterruptible power supply ‘B’ (UPS ‘B’).
- For modeling considerations, the two maintenance power ties (outlined in the main text are not considered part of the model.
- A single commercial utility power delivery feed was included in the model, though the availability of that feed was “set to zero” to demonstrate the independence (exclude outside power utility usage) of the model.
- Each zone is capable of delivering 100 percent of the required power to the given zone and mission command center (zone 5).
- Each “zone load output” supplies power to the electric and mechanical systems within the specified zone.
- In order to provide 2 of 4 HVAC operation (zones 1-4), 2 of 4 electric power delivery is necessary to support that function. Likewise, 2 of 4 HVAC available systems are necessary.
- In order to maintain balanced air pressure within the building, 2 of 4 air handling units (AHU) are necessary (for compensated zones 1-4). Additionally, 2 of 4 makeup air handling (MAH) units are necessary for zone 5 support.
- Due to facility capability size, first and second floors contain computer air conditioning units (CAC) are in the necessary 4 of 6 and 2 of 4 configurations, respectively.

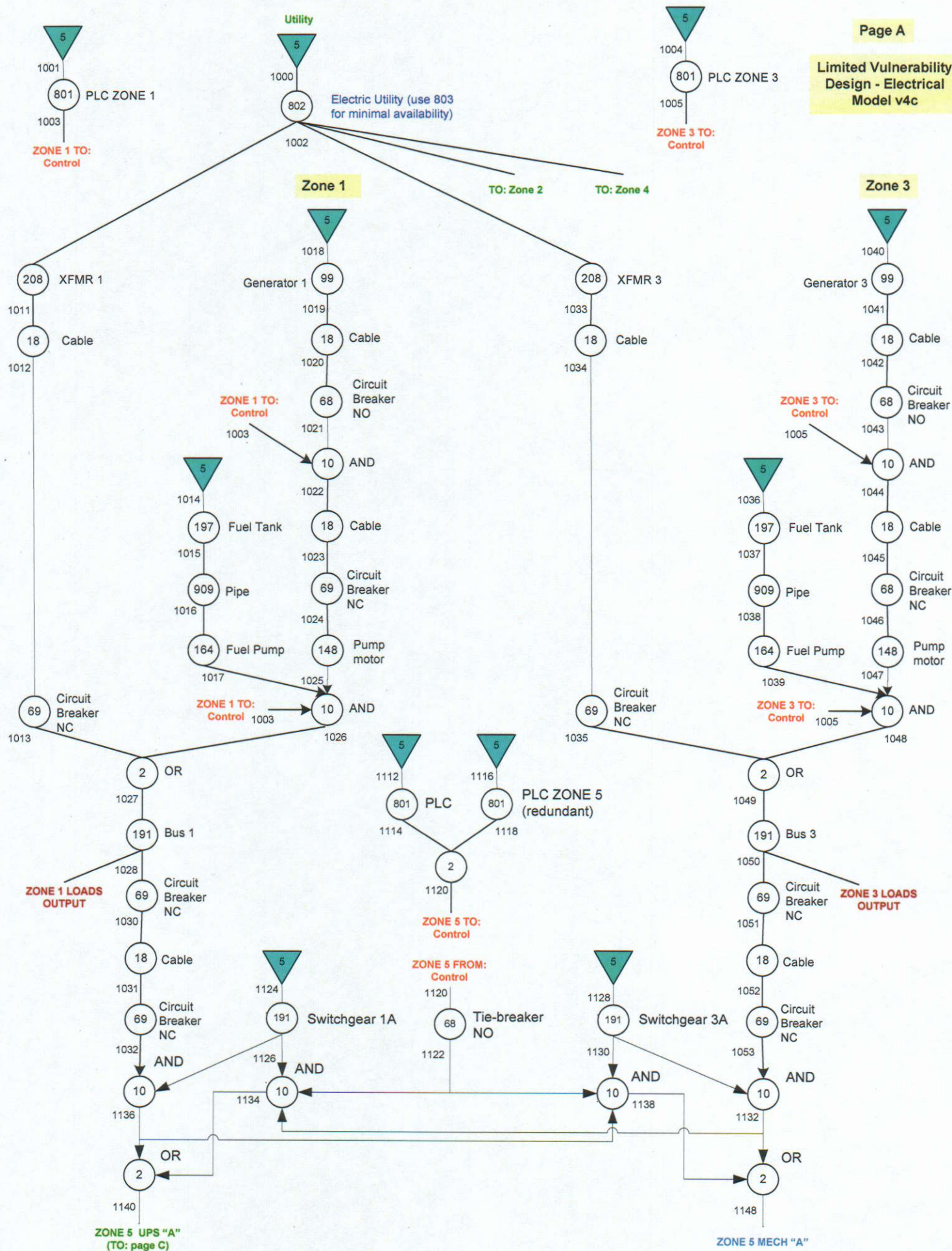
- Make-up water for each zone includes a reserve water tank. Additionally, two independent water sources are included but modeled with minimal availability (to show independence from commercial utility resources).
- Commercial electric power availability is set to a minimum (to show independence from commercial utility resources).
- The model includes major component systems but does not include in-depth detail (including wiring, control and support components).
- Reliability data used for the model components were selected according to design criteria and the specific applications outlined in the main text.
- Commercial water supplies for the mission site were included in the model to demonstrate where they would “normally” connect in with the water delivery system. However, mathematically they were removed by assigning “zero” to the inherent availability value, insuring independence of external water supplies at the mission site.

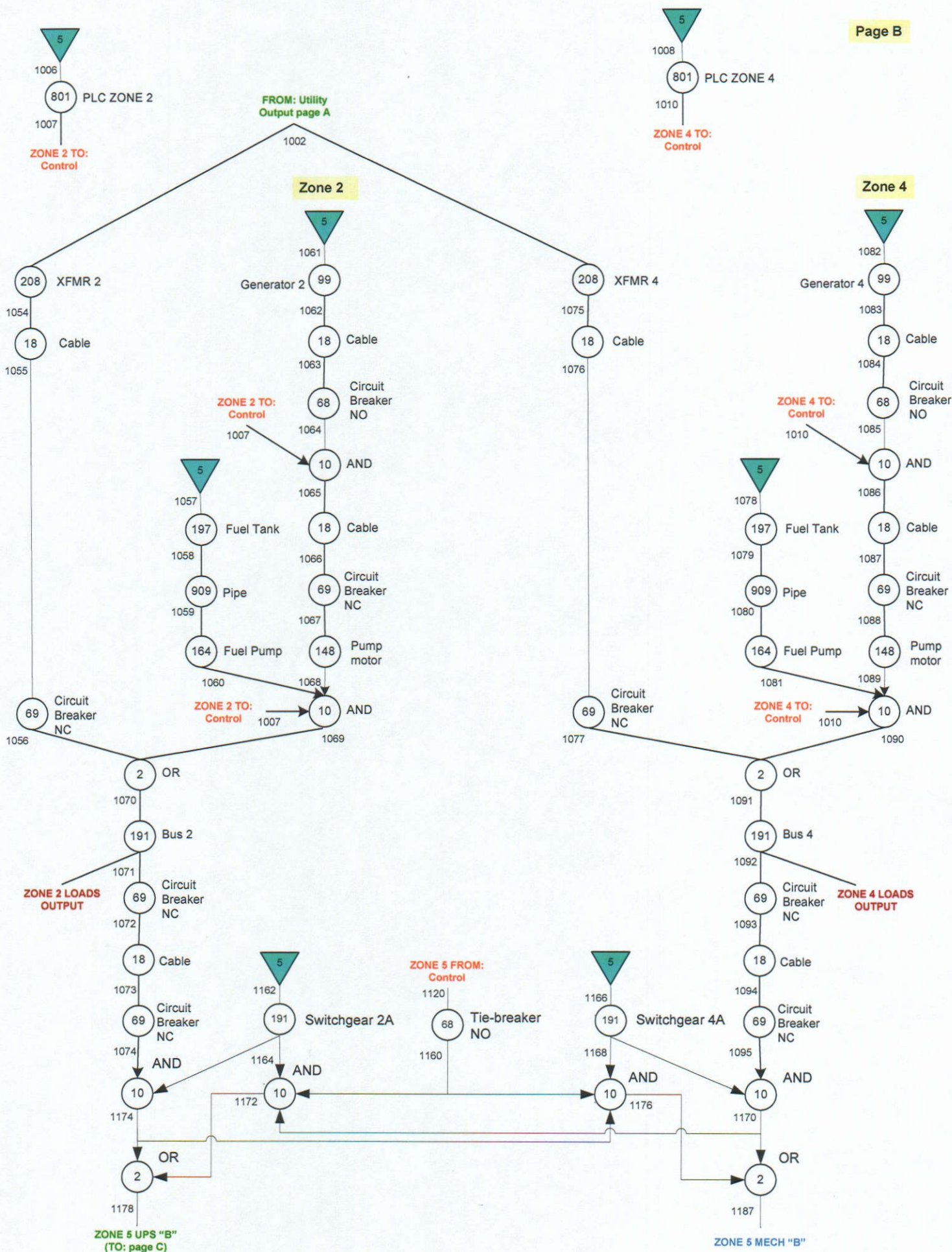
Analysis Results:

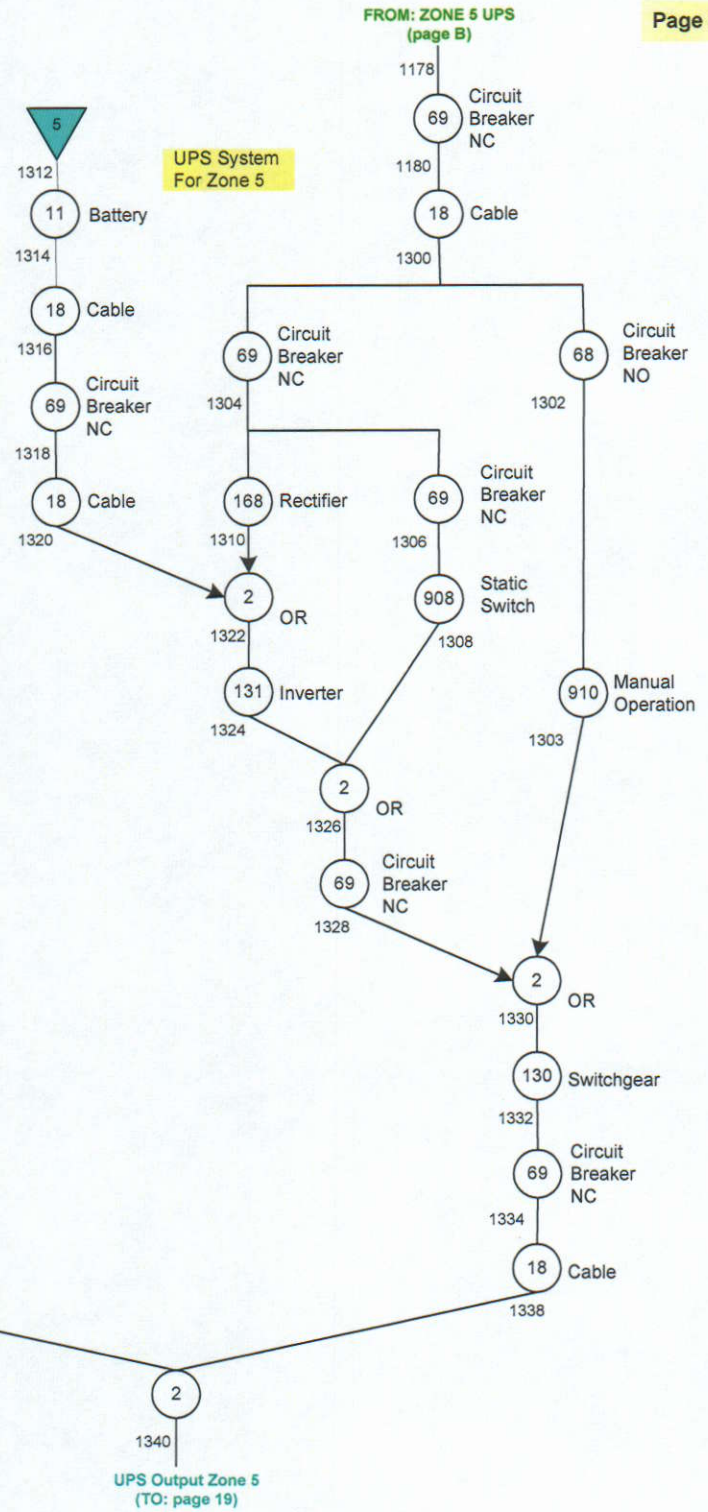
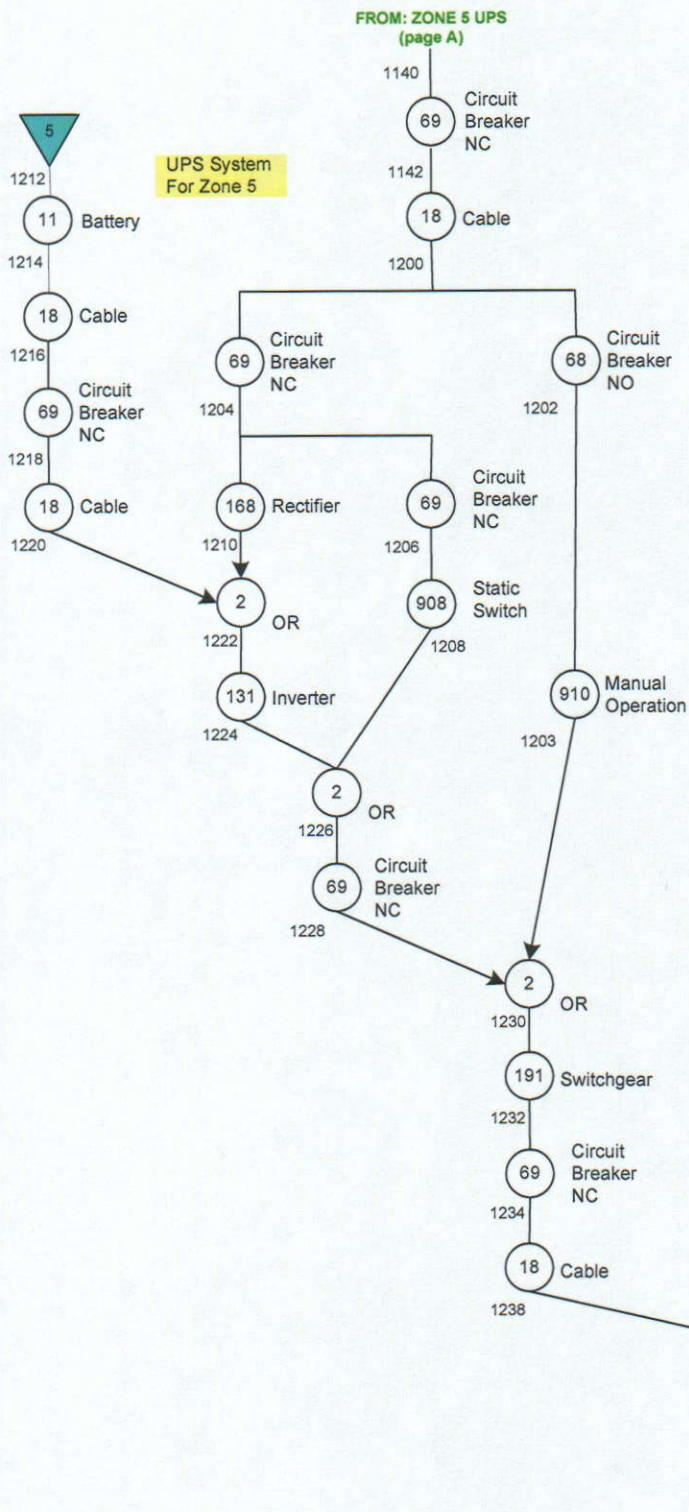
The results of the analysis have shown that the concept model for mission critical power and mechanical (HVAC) availability is robust, insuring that the facility meets the criteria of 6-9s availability. Hence, the design demonstrates that a C4ISR installation designed, using the Limited Vulnerability Design criteria can be built and operated globally, regardless of the ability to be supplied by existing commercial power and water delivery facilities. For comparison purposes, the inherent availabilities for various model signal points can be reviewed on the table, located on page 20 of the model summary.

Overall Conclusions:

1. The electrical power and mechanical HVAC delivery concept model described in main text of technical manual provides an overall availability (inherent) to the critical mission (zone 5) of greater than 6-9s, regardless of whether commercial water and electric power utilities are available at the facility site.
2. Because the model availability (inherent) is greater than 6-9s, sensitive electromechanical systems can operate with minimal disruptions.
3. With an availability (inherent) greater than 6-9s (excluding external electric power and water) the location of a C4ISR facility can be designed according to this criteria and located globally.

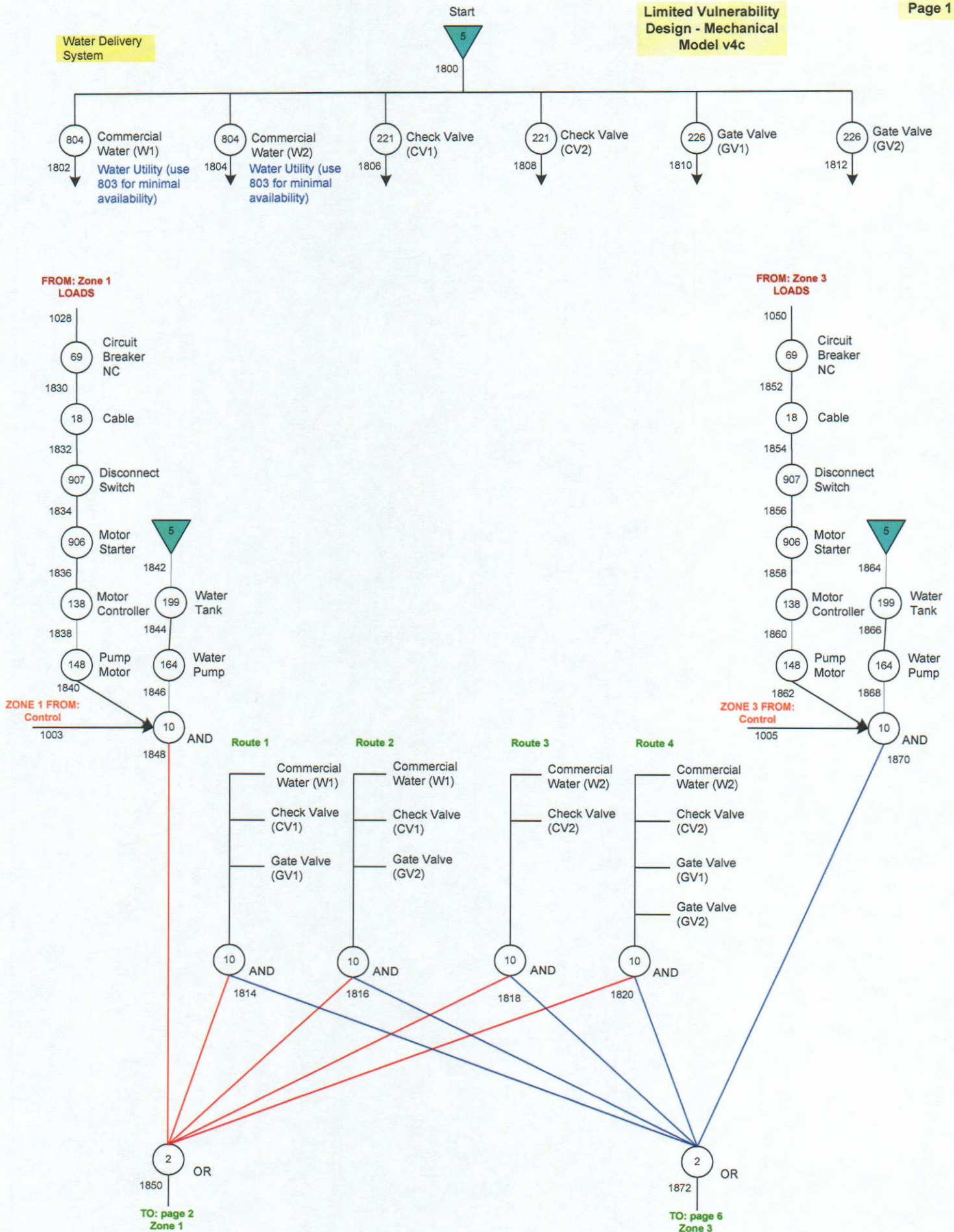


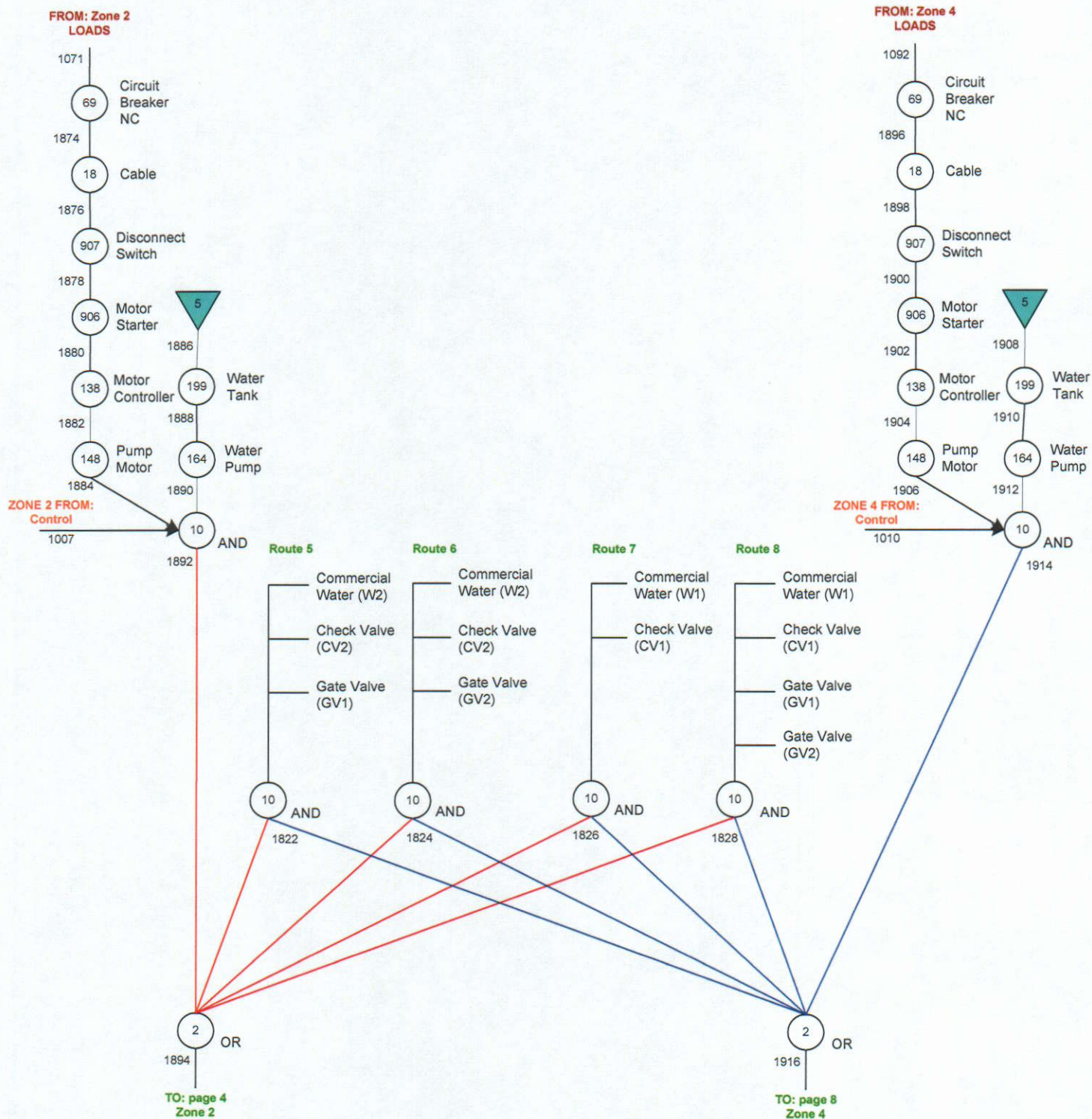


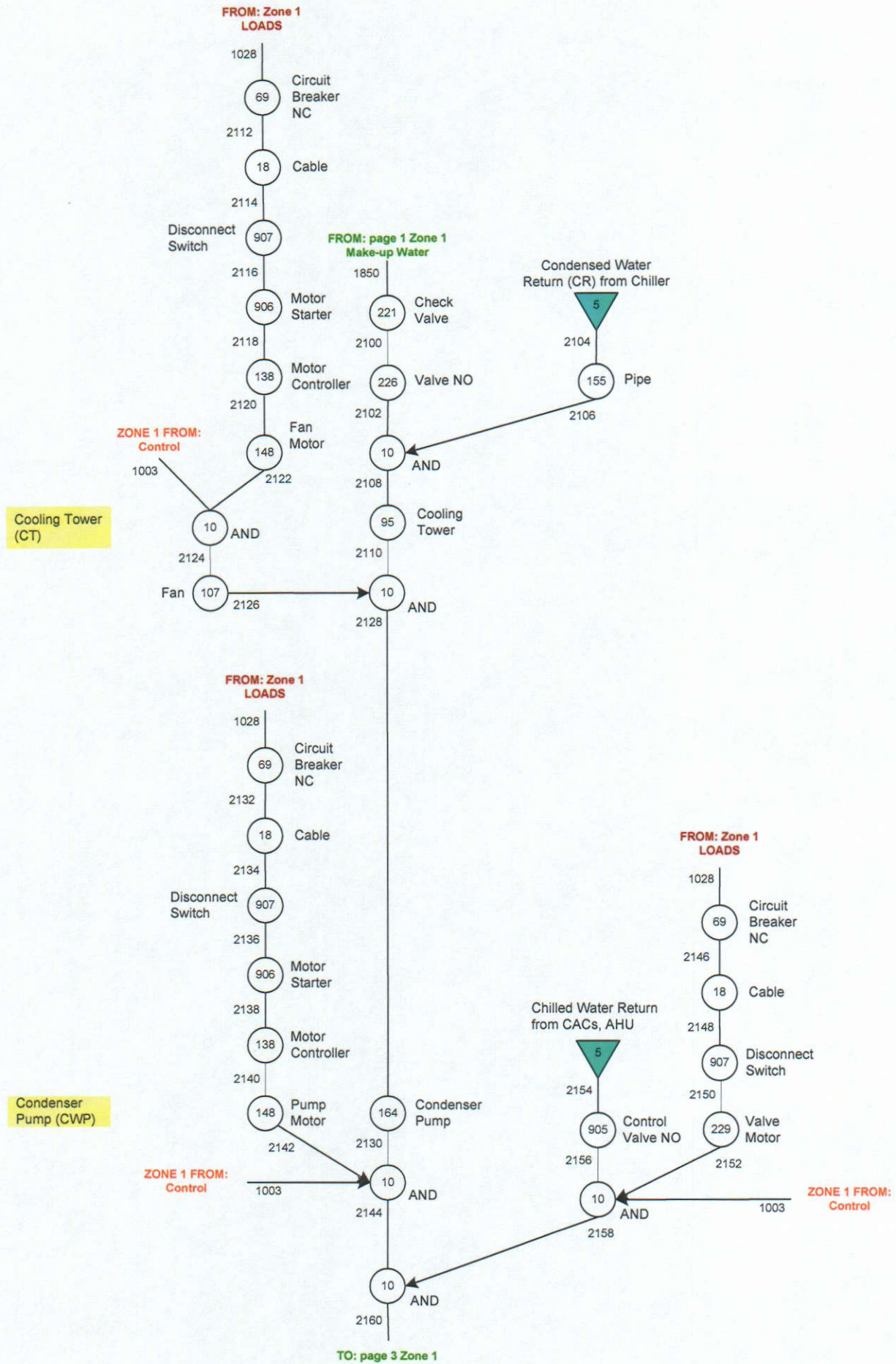


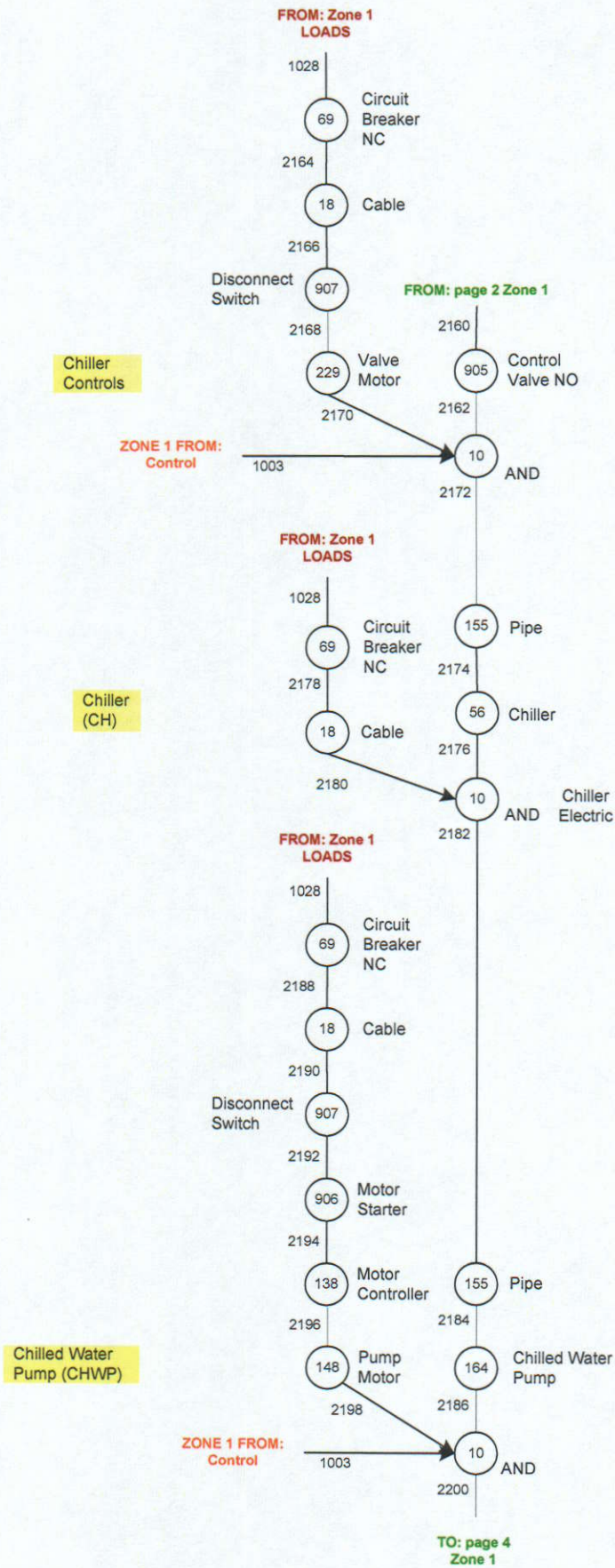
Water Delivery System

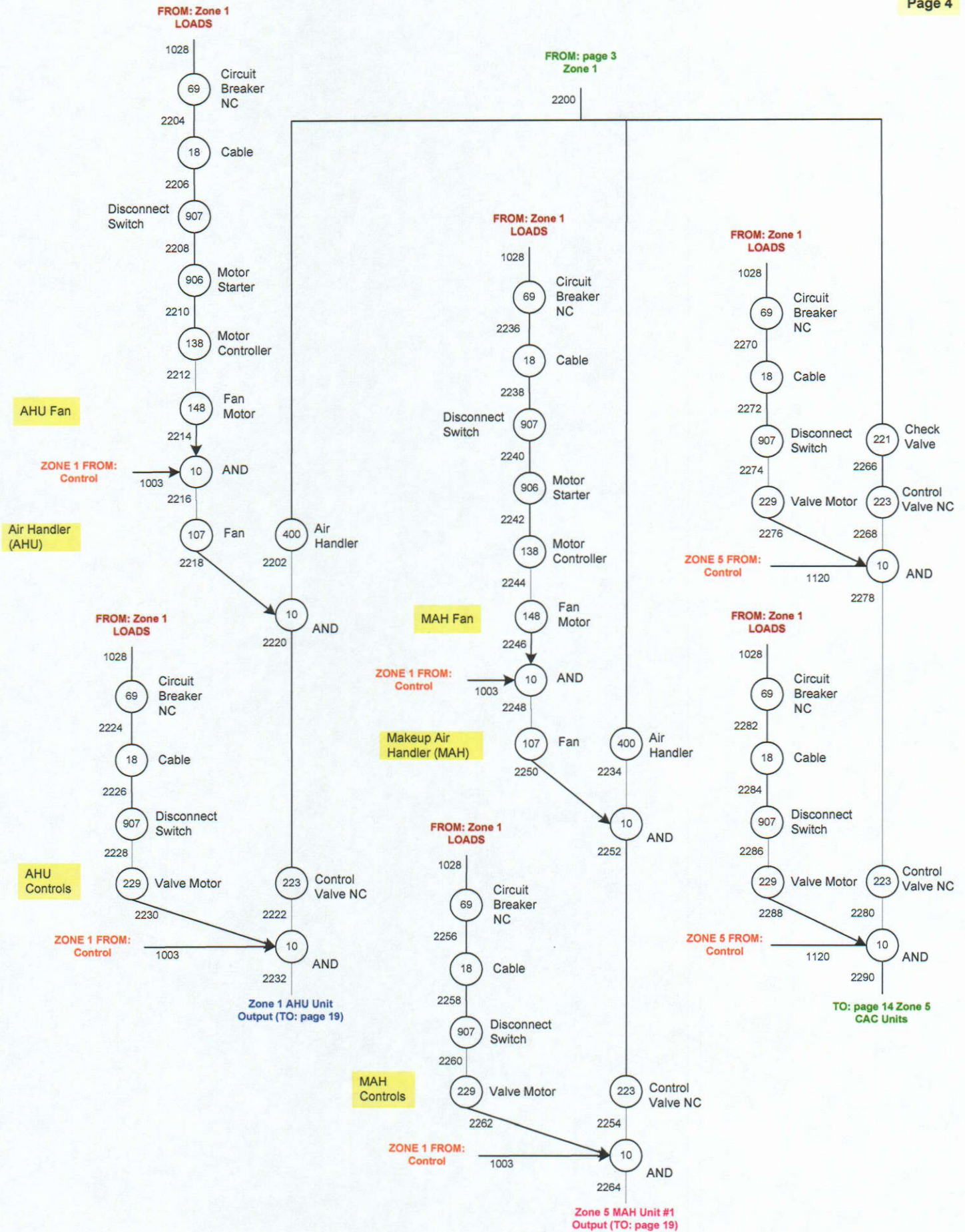
Limited Vulnerability Design - Mechanical Model v4c

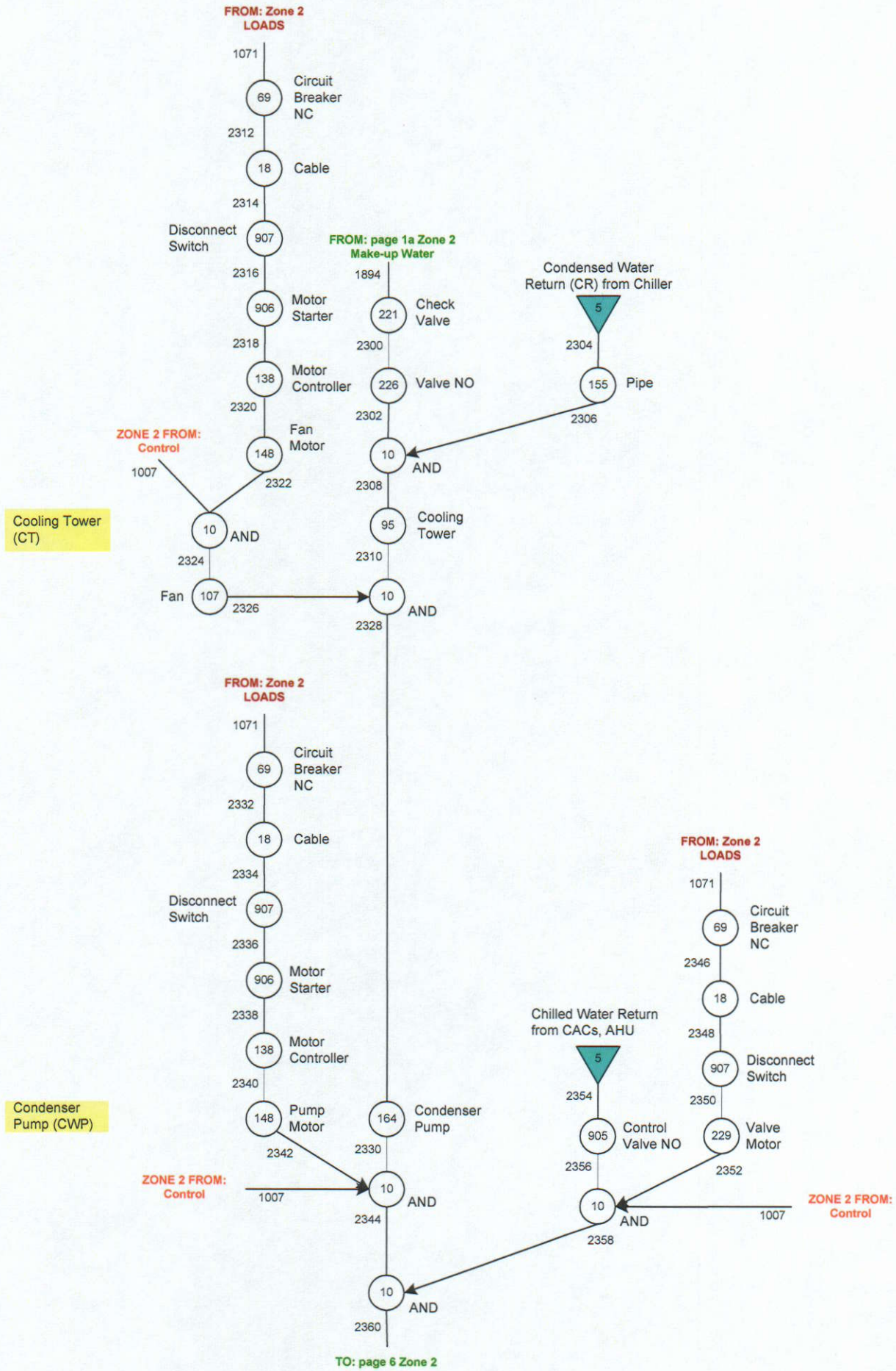


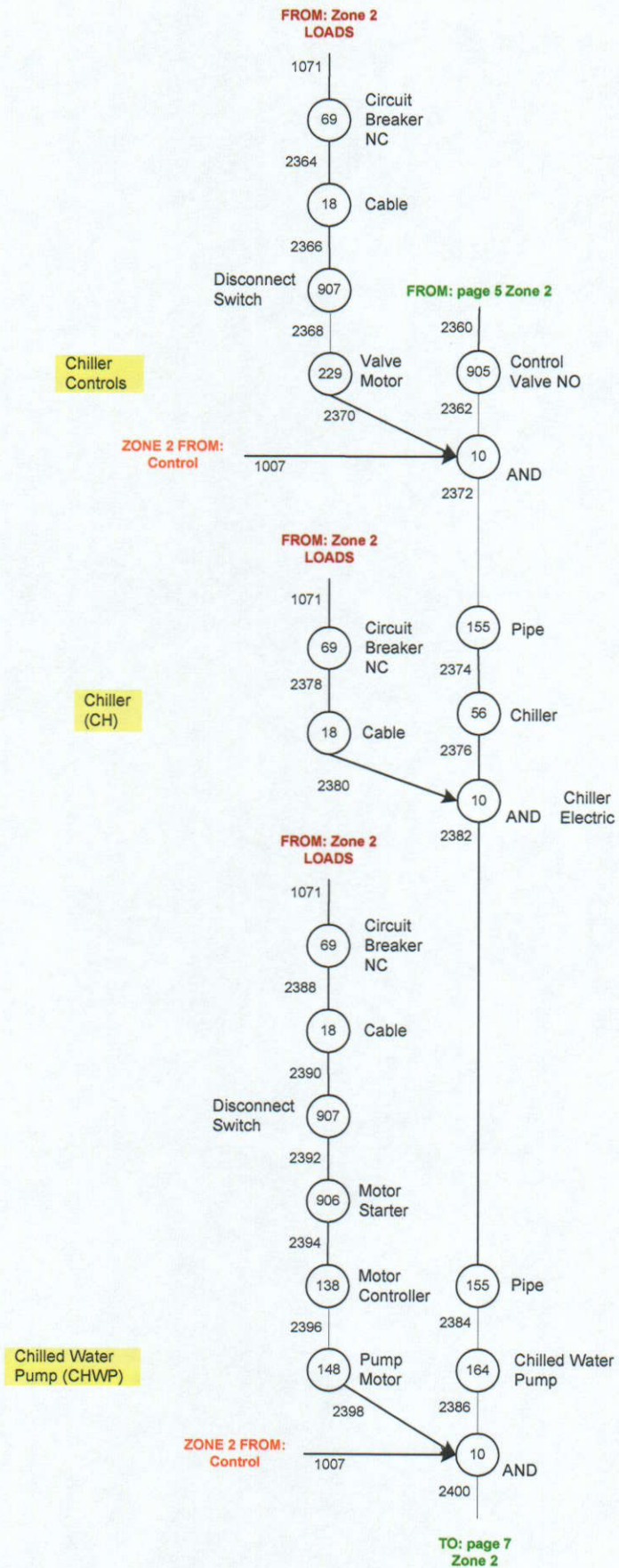


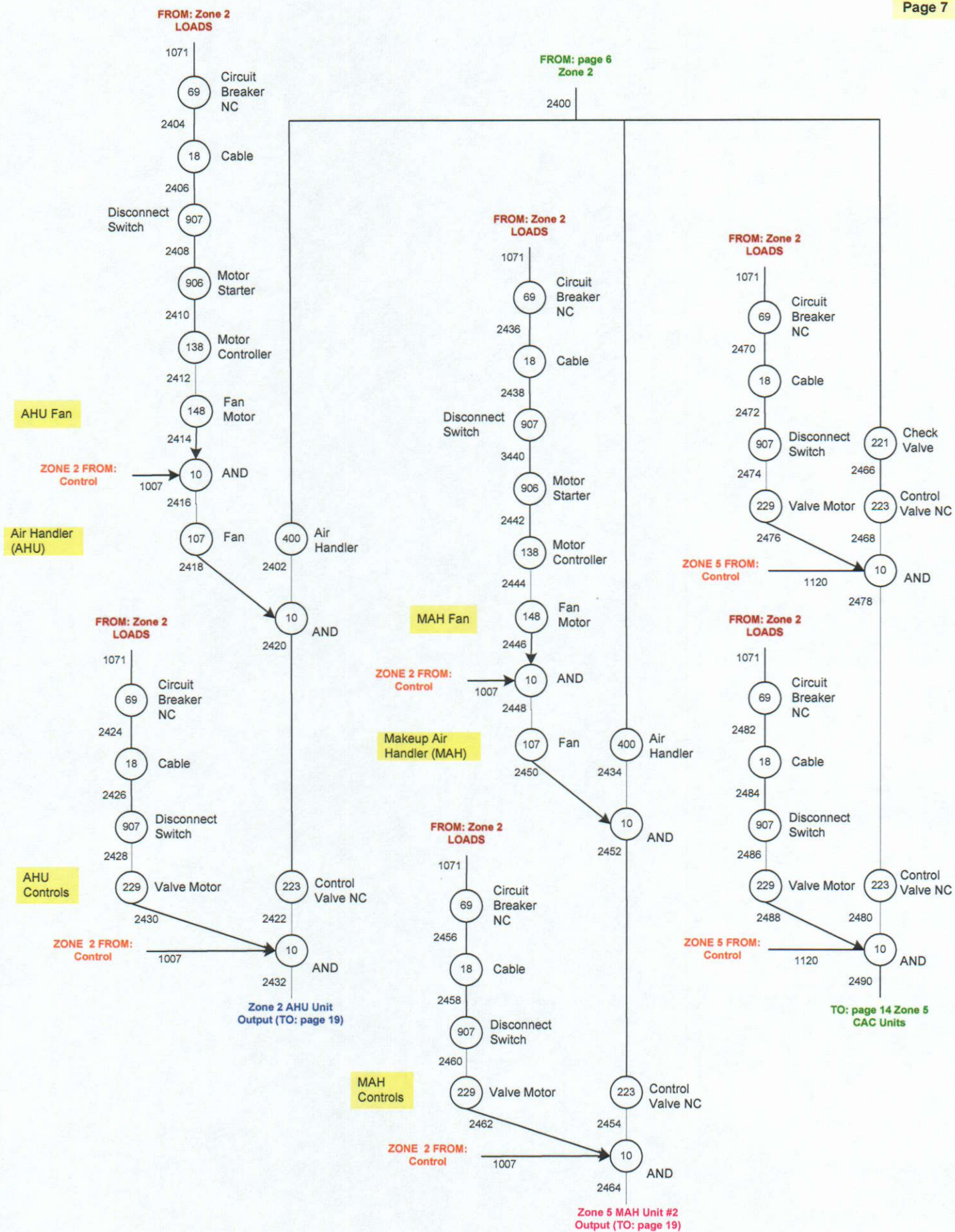


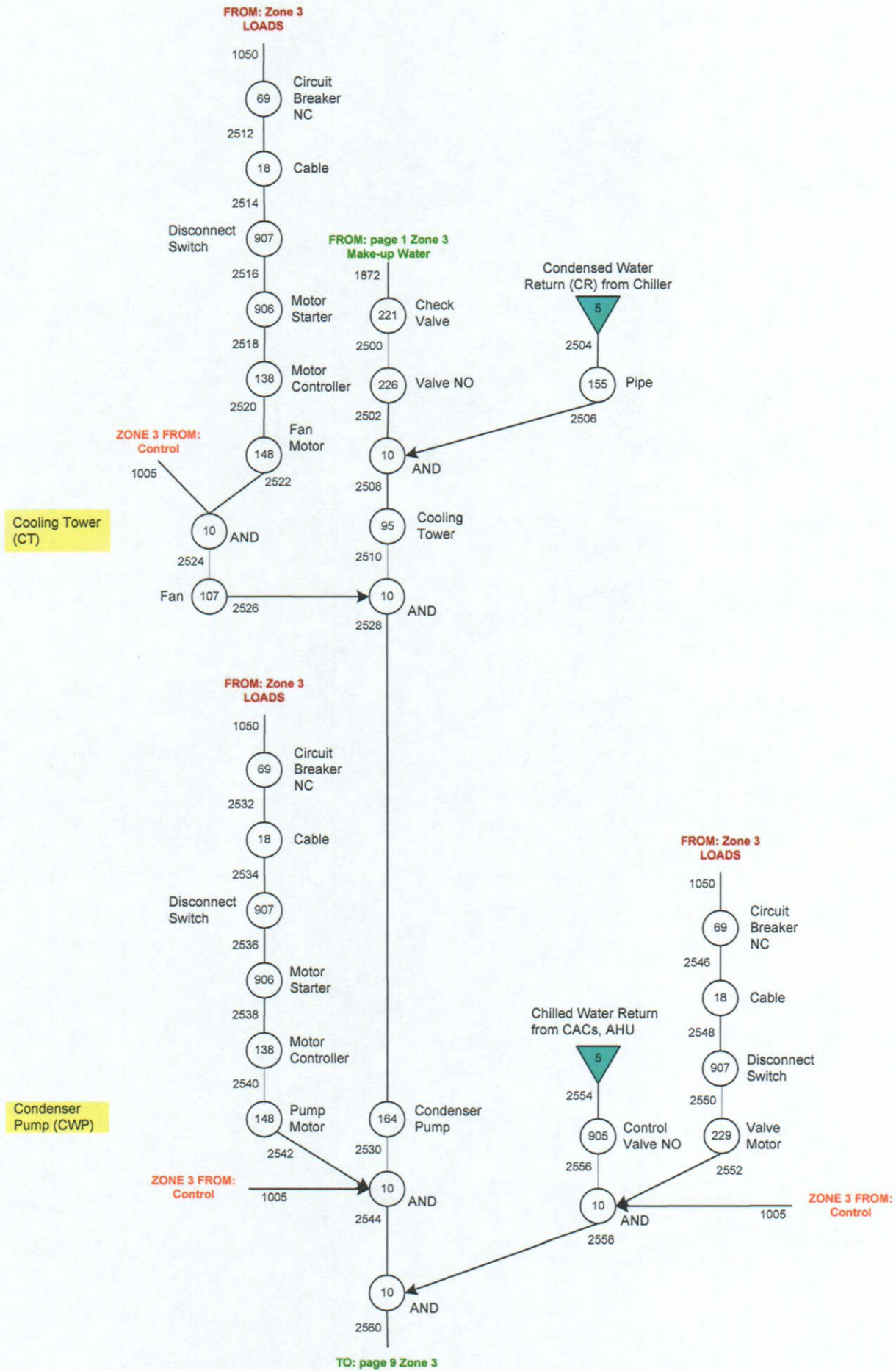


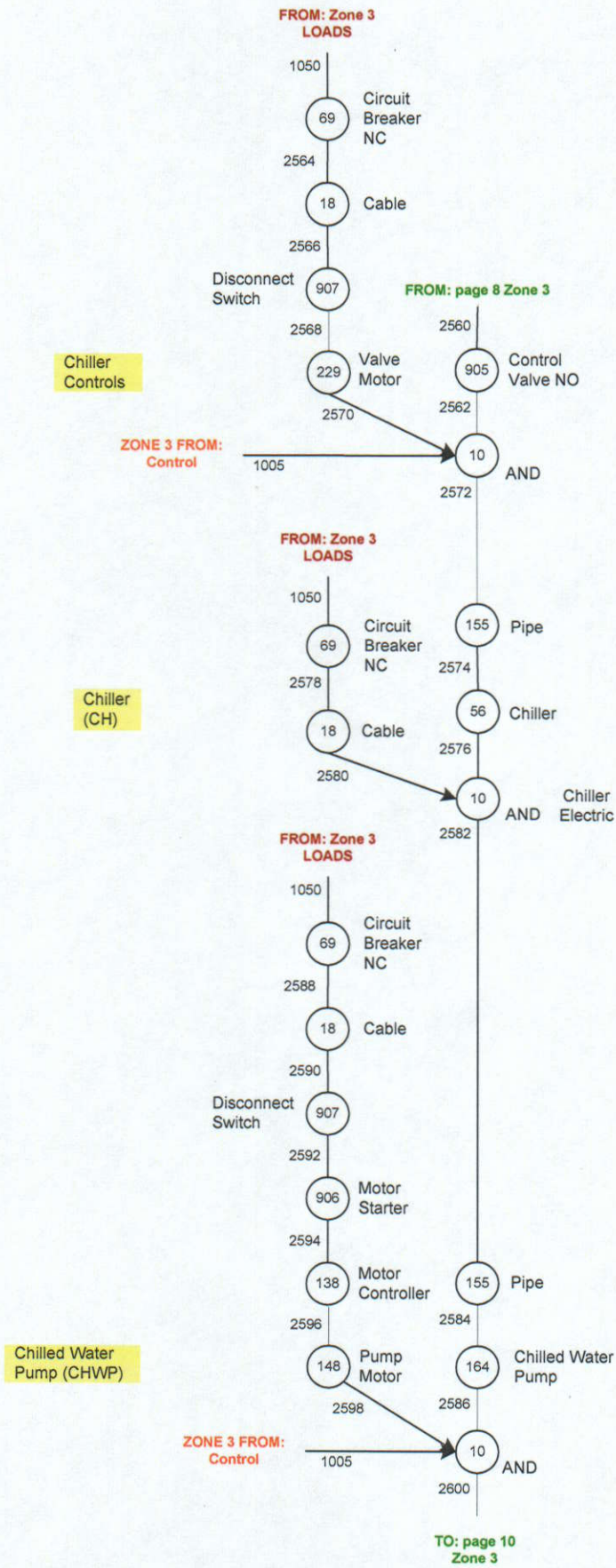


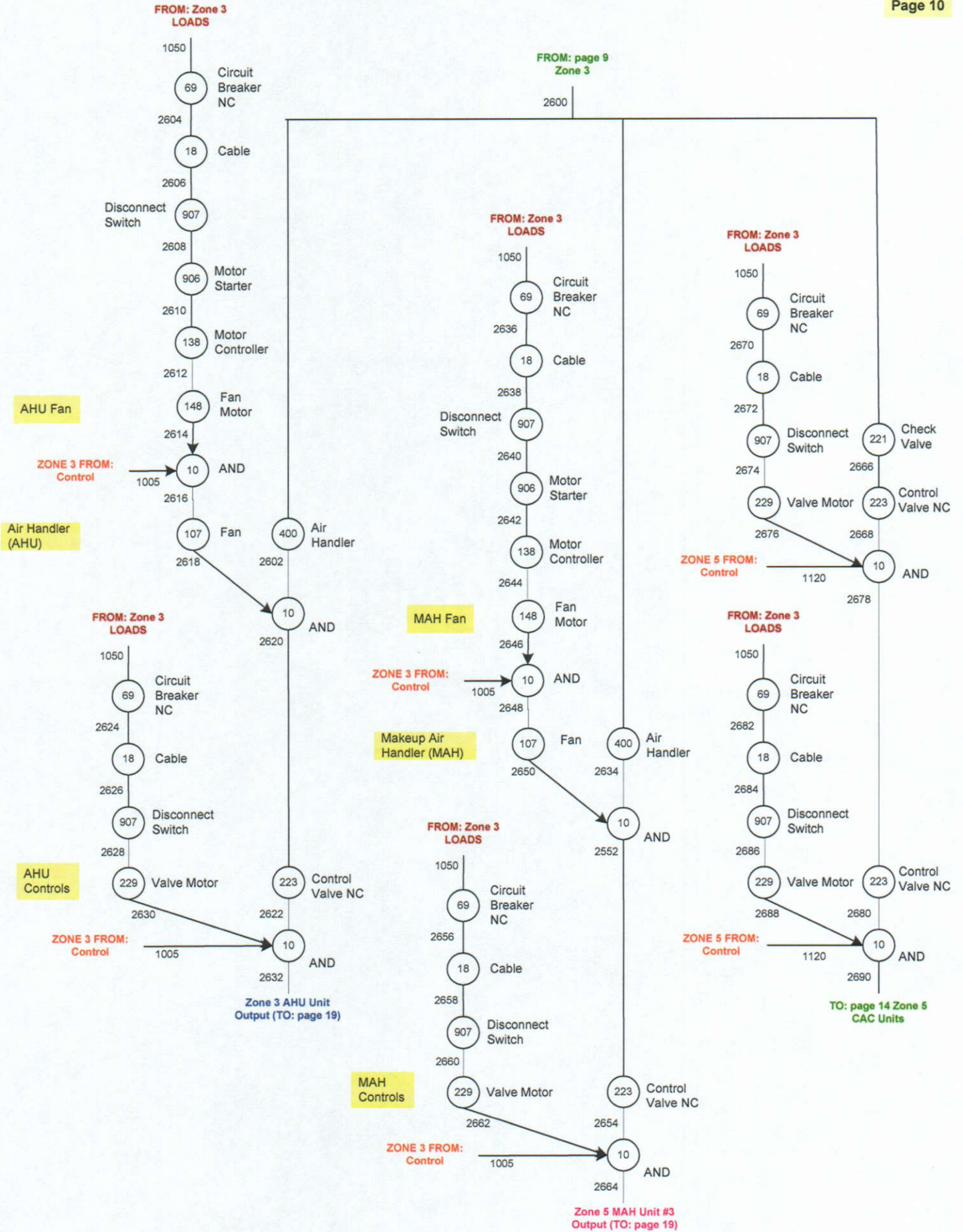


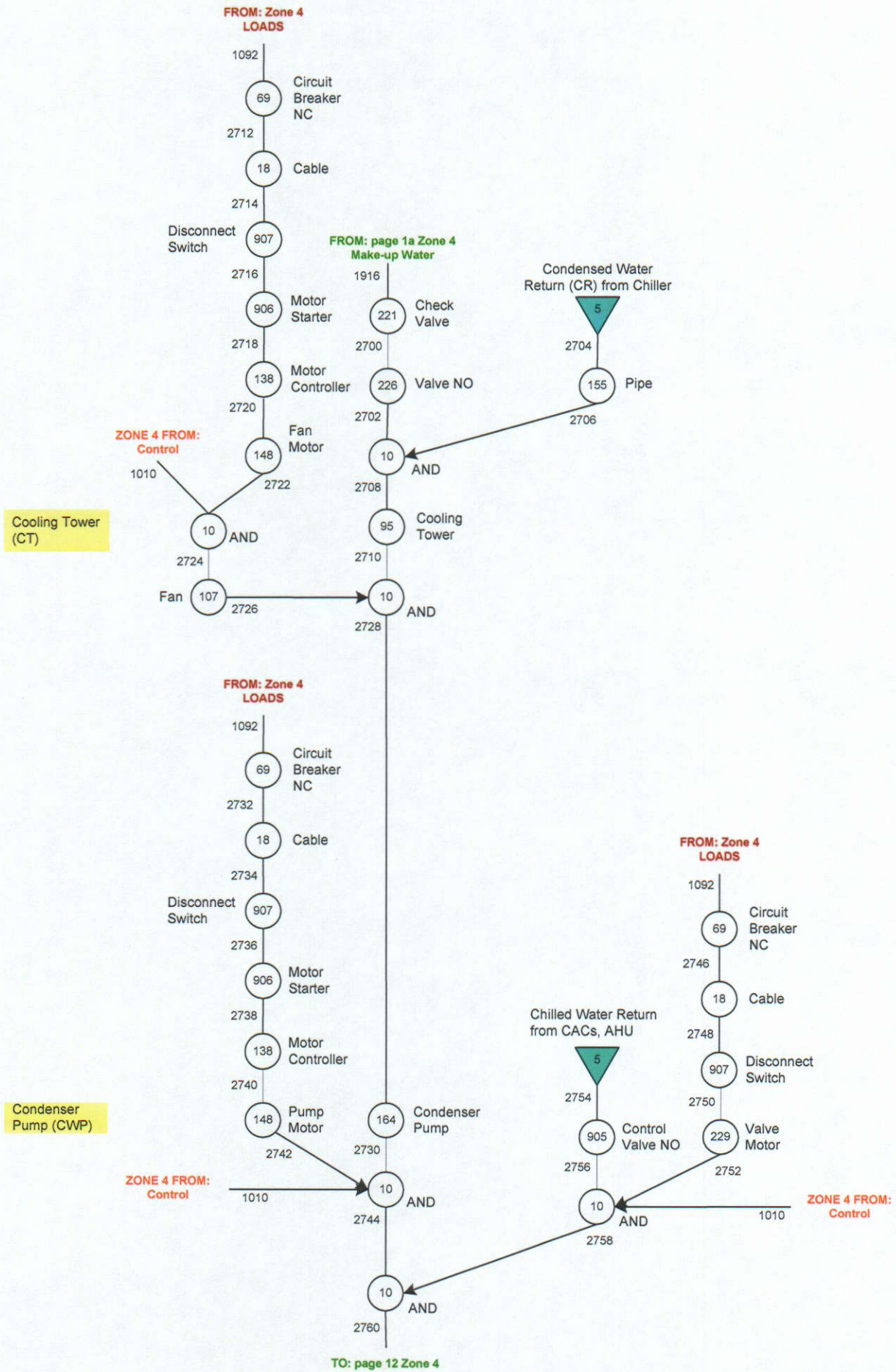


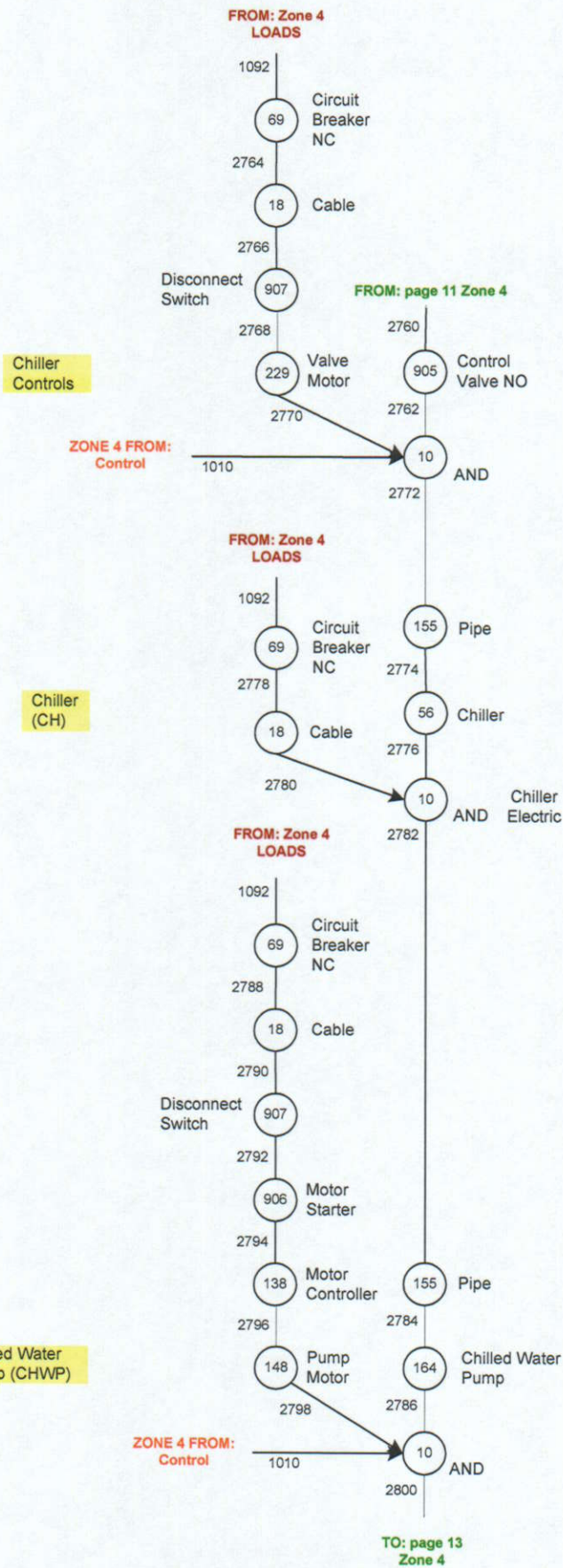


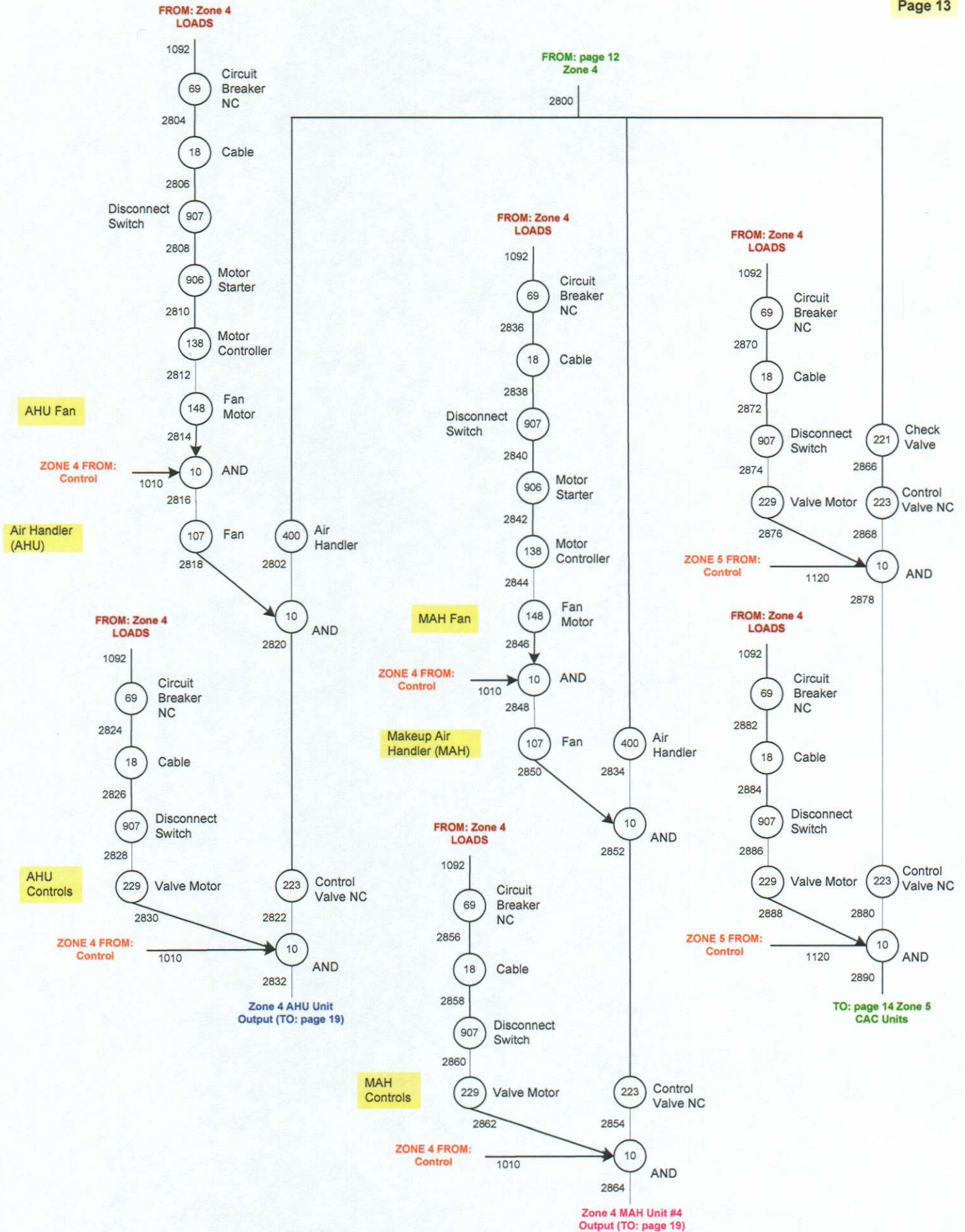


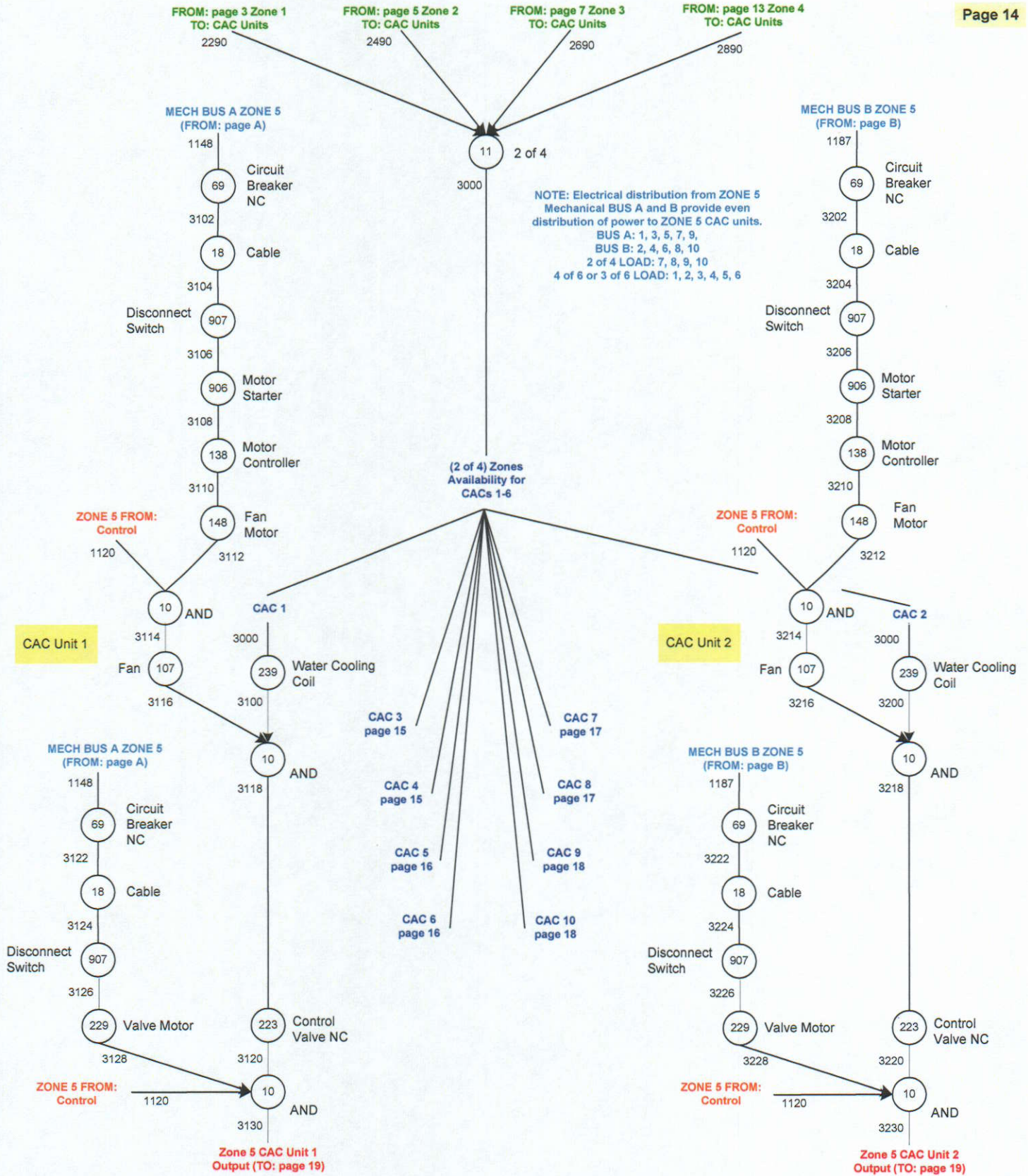


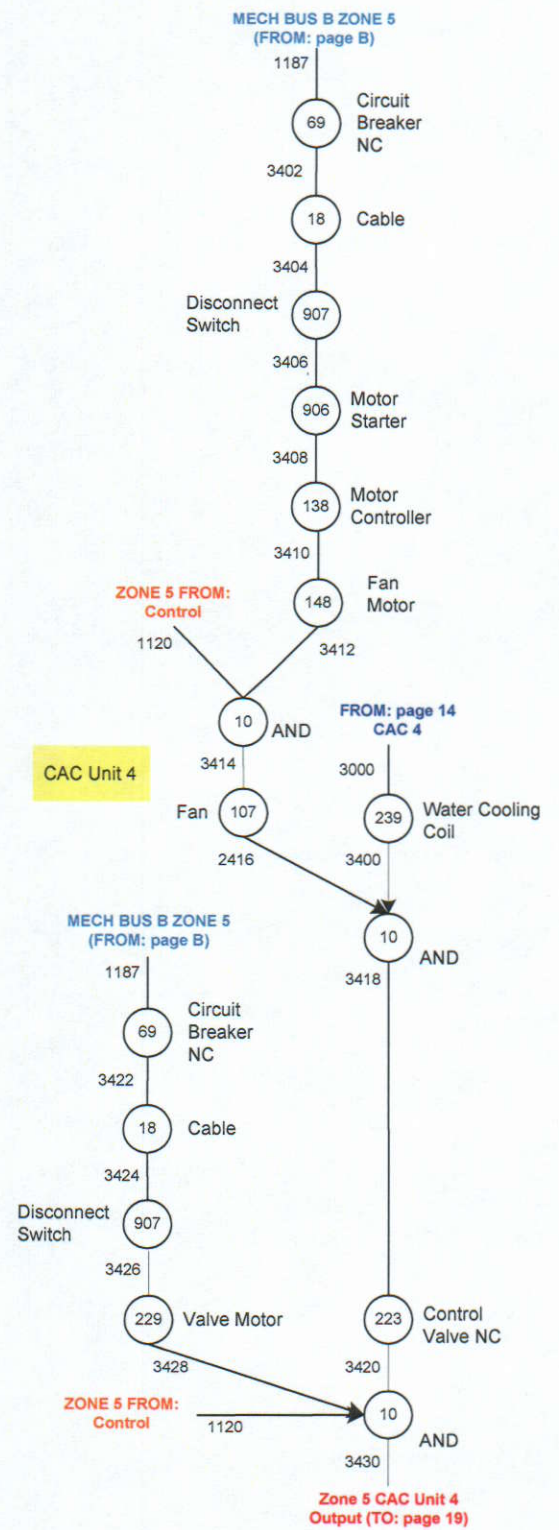
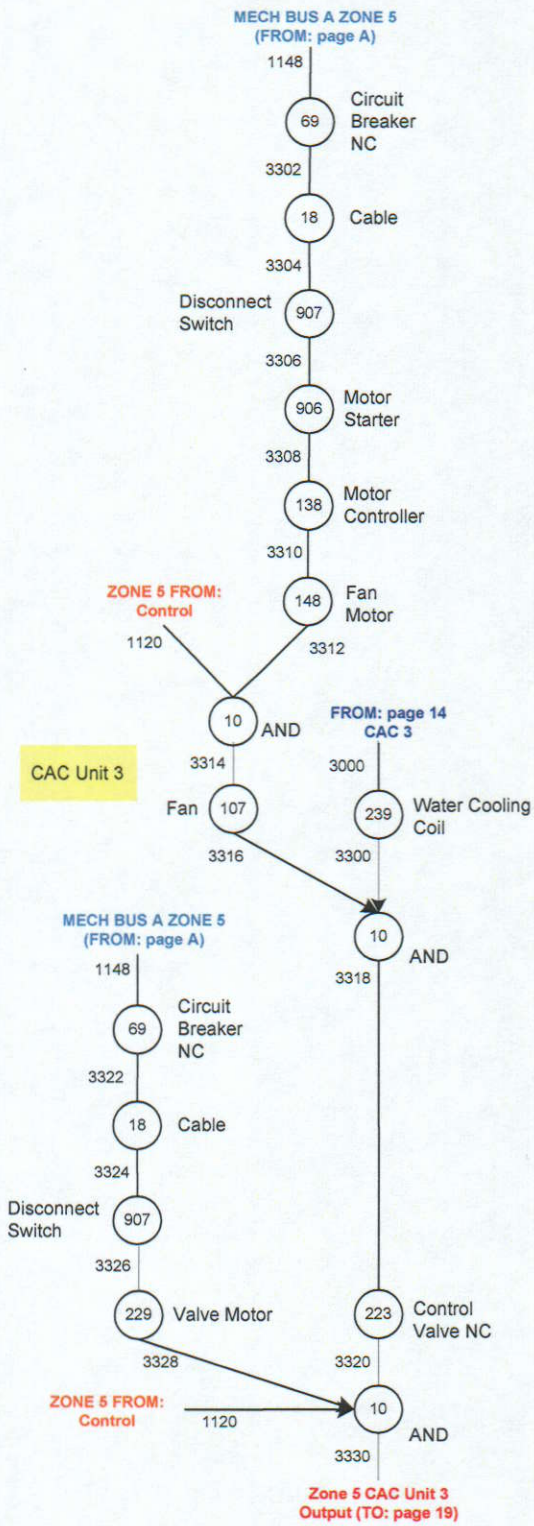


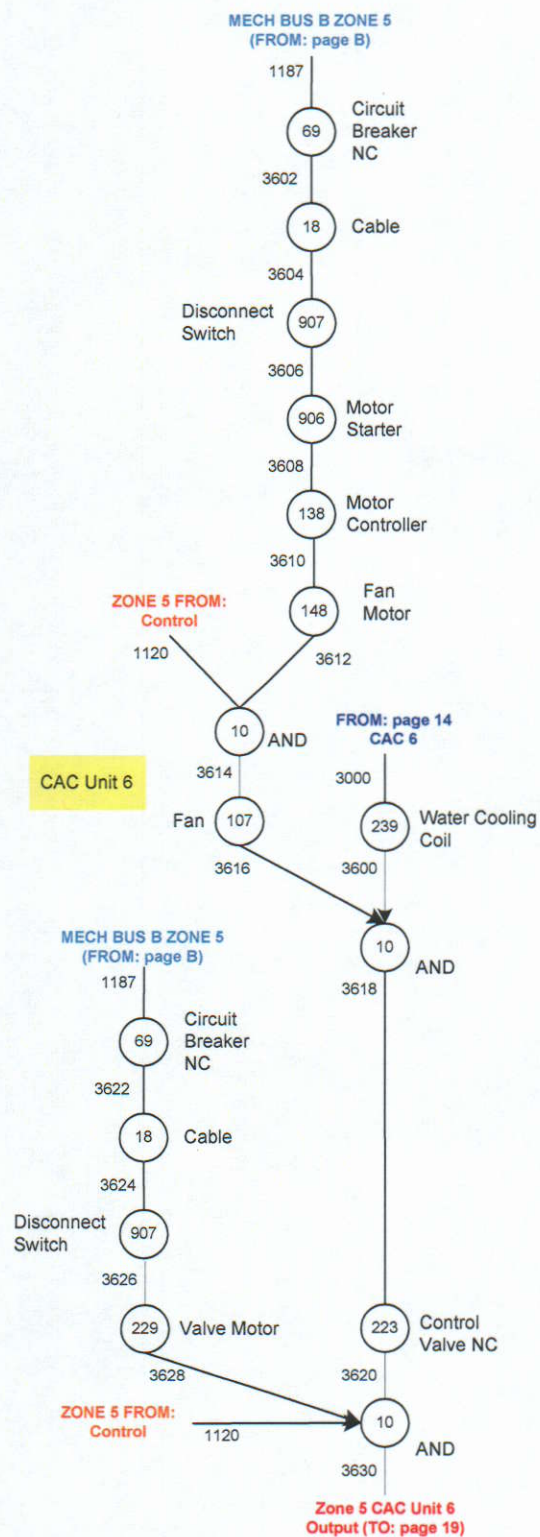
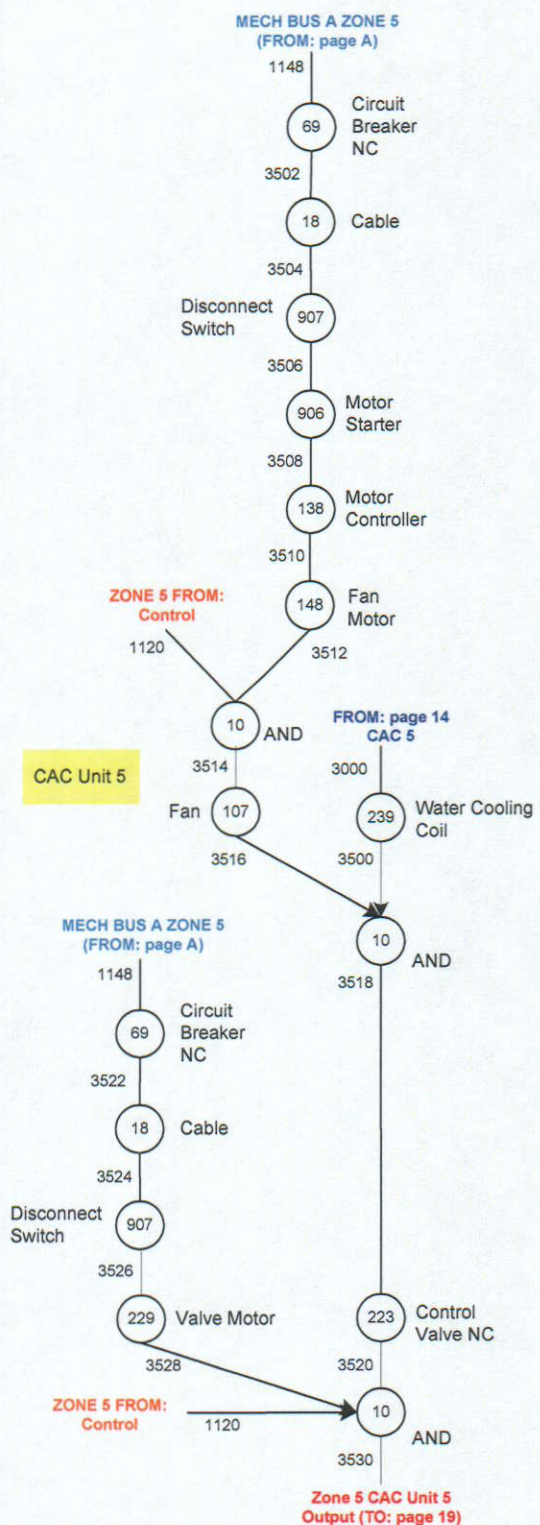


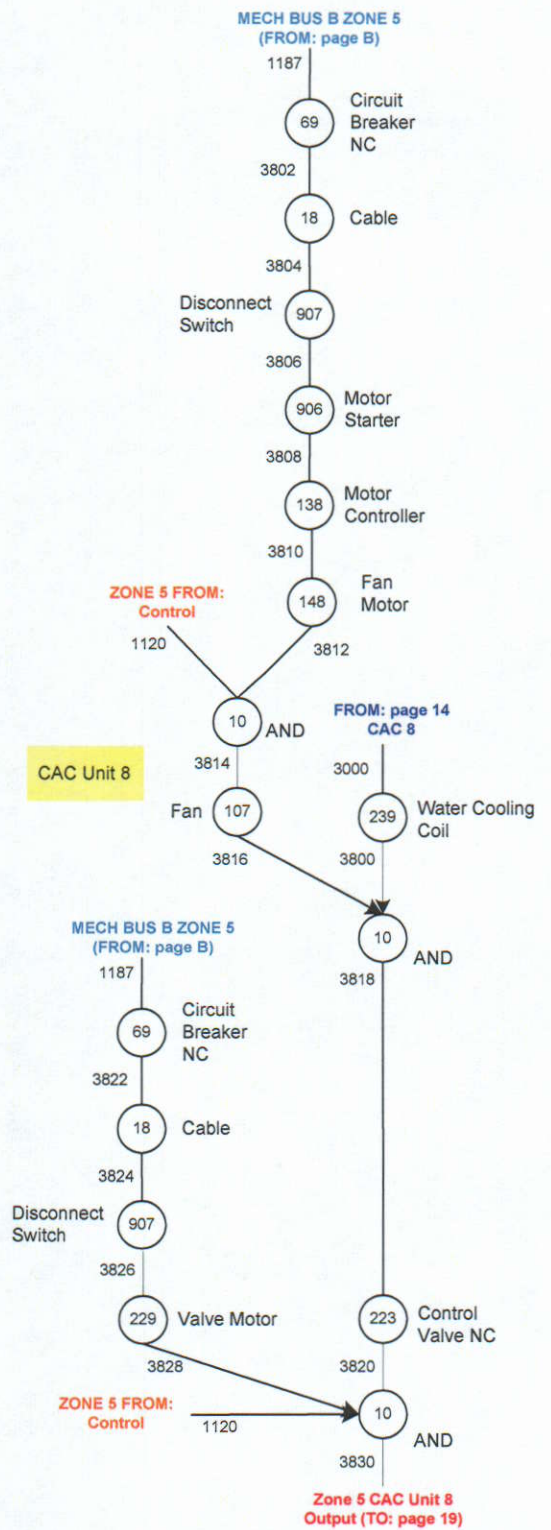
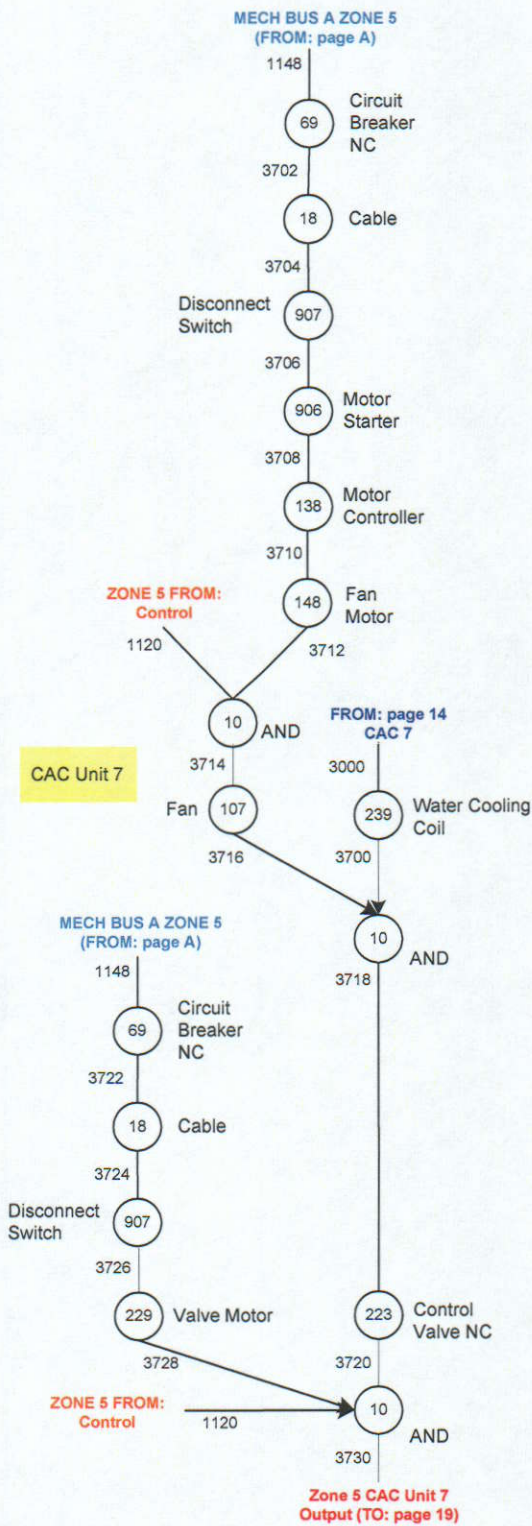


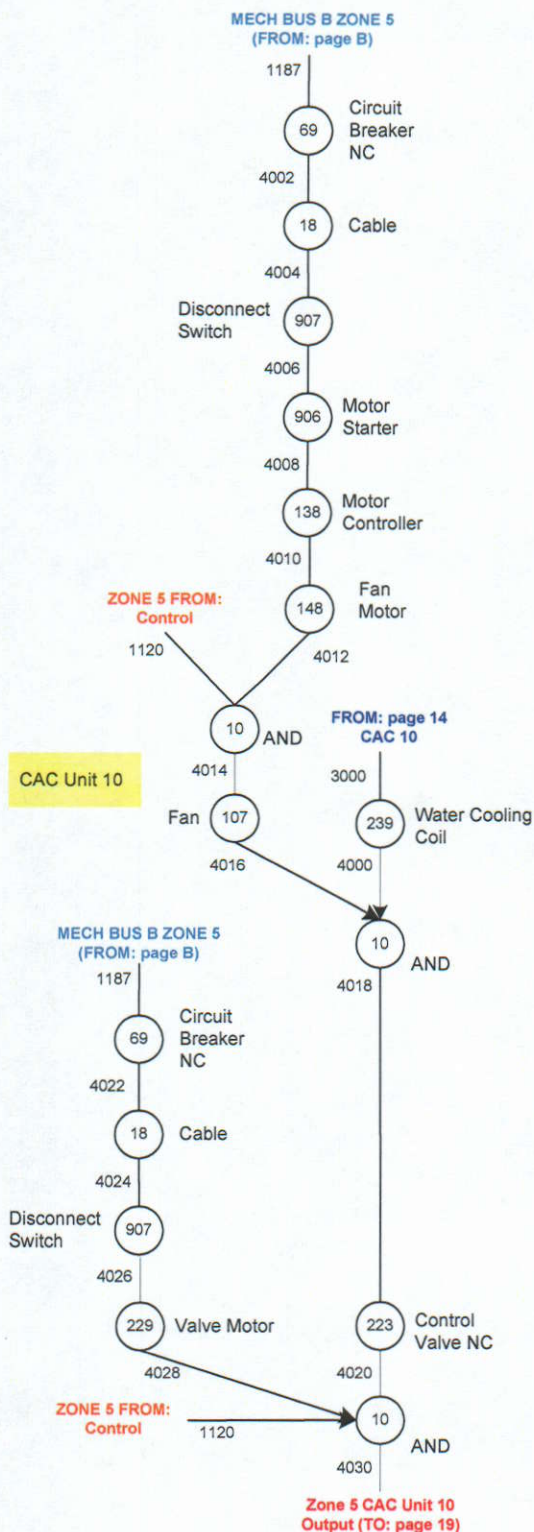
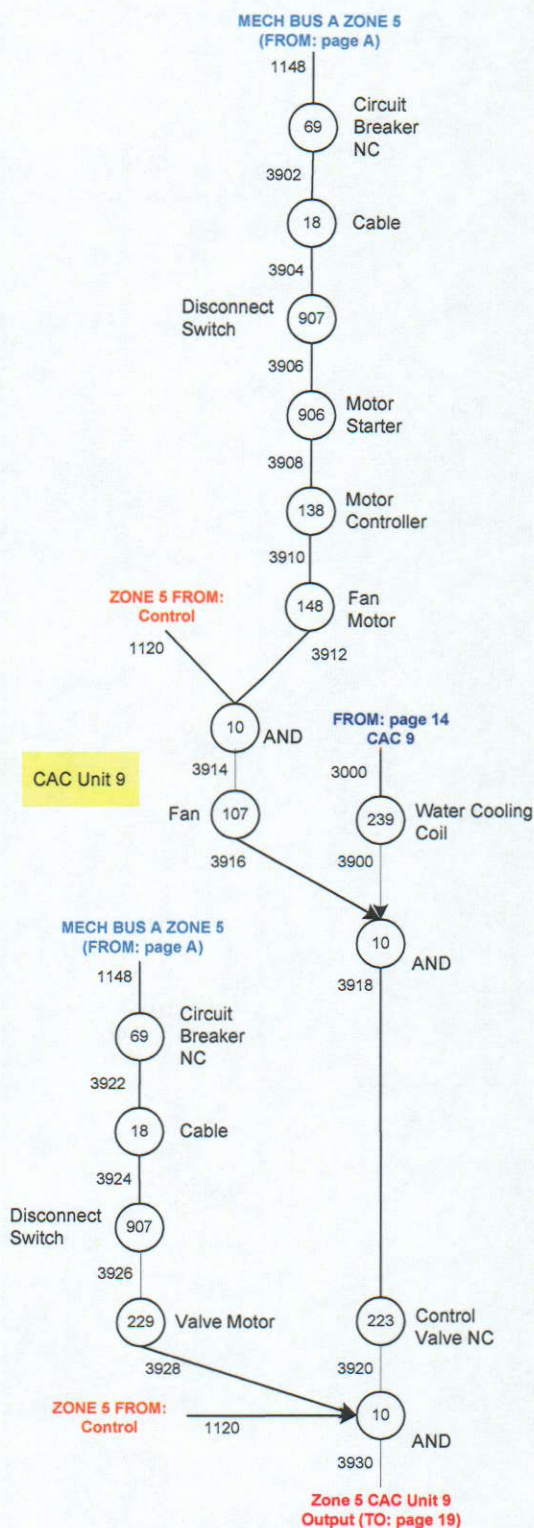


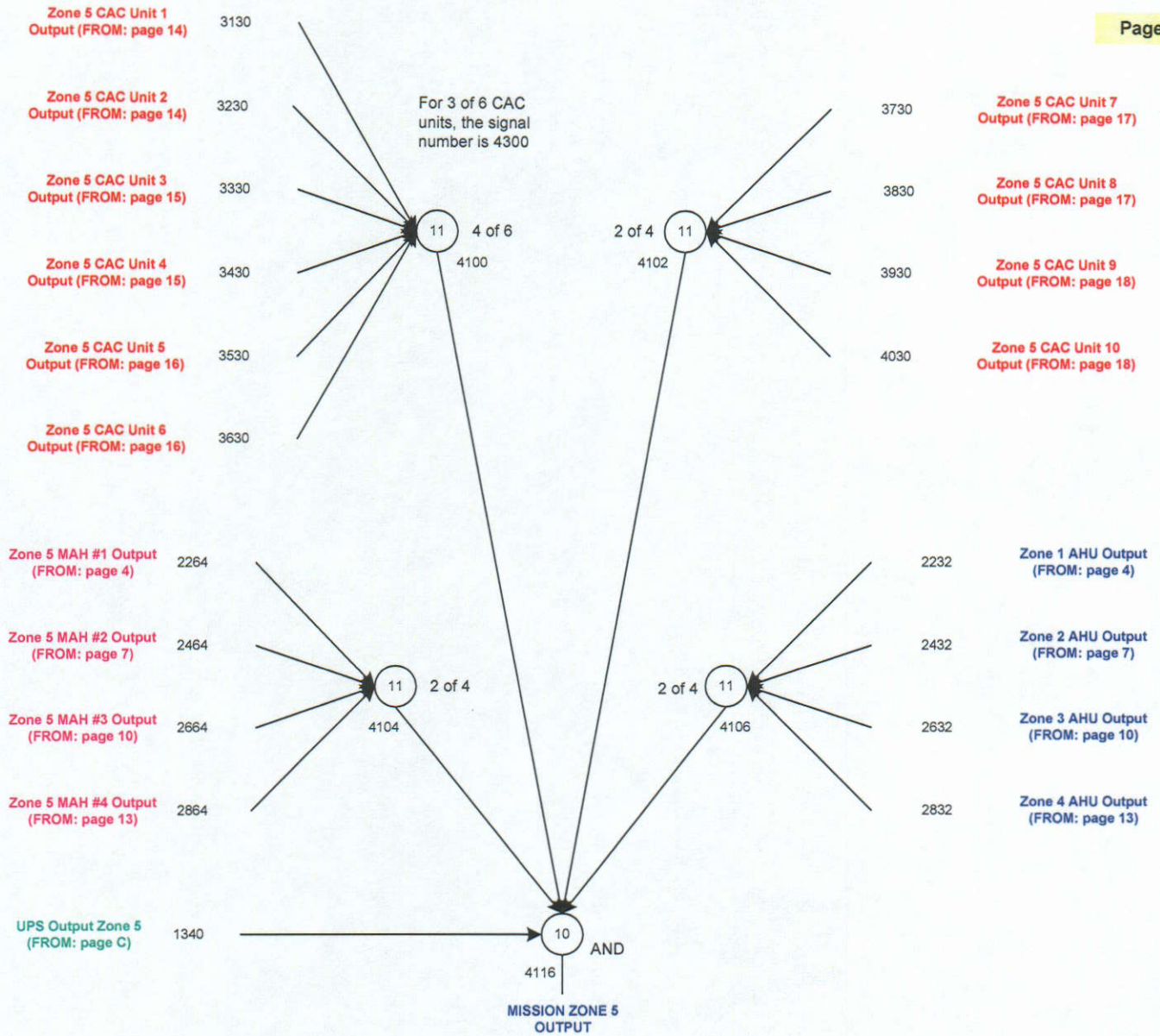












See page 20 for other potential output signal variations to achieve the mission (as defined on page 20).

<u>Availability at:</u>	<u>Signal Point</u>	<u>Signal</u>	<u># 9's</u>	<u>Notes</u>
Zone 5 UPS	1340	1	>7-9	
Zone 5 Mech A	1148	0.99998821	4-9	
Zone 5 Mech B	1187	0.99998821	4-9	
4 of 6 CAC	4100			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 1-4 AHU	4106			
AND	4108	0.99997635	4-9	
3 of 6 CAC	4103			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 1-4 AHU	4106			
AND	4110	0.99999987	6-9	
4 of 6 CAC	4100			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
AND	4112	0.99997635	4-9	
3 of 6 CAC	4103			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
AND	4114	0.99999988	6-9	
4 of 6 CAC	4100			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 1-4 AHU	4106			
Zone 5 UPS	1340			
AND	4116	0.99997635	4-9	(Combination represented in model - page 19)
3 of 6 CAC	4103			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 1-4 AHU	4106			
Zone 5 UPS	1340			
AND	4118	0.99999987	6-9	
4 of 6 CAC	4100			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 5 UPS	1340			
AND	4120	0.99997635	4-9	
3 of 6 CAC	4103			
2 of 4 CAC	4102			
Zone 1-4 MAH	4104			
Zone 5 UPS	1340			
AND	4122	0.99999988	6-9	